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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F16F 15/00

A2

(11) International Publication Number: WO 98/16760

(43) International Publication Date: 23 April 1998 (23.04.98)

(21) International Application Number: PCT/GB97/02730

(22) International Filing Date: 6 October 1997 (06.10.97)

(30) Priority Data:
9621498.6 15 October 1996 (15.10.96) GB

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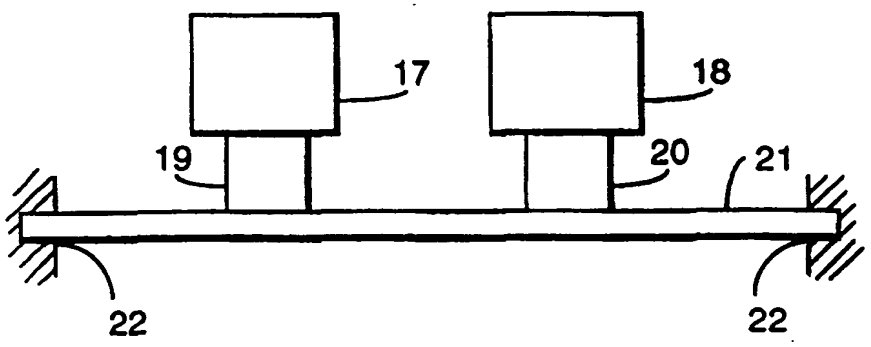
(81) Designated States: AU, BR, CA, GB, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: VIBRATION ATTENUATION SYSTEM

(57) Abstract

A vibration attenuation system comprises at least one operative machine (17), one idle machine (18) and a support (21). Each machine (17, 18) is mounted on the support (21) via respective operative and idle mounts (19, 20). The stiffness of each mount (19, 20) may be switched between an isolation mode and an absorption mode. The stiffness of the operative mount is switched to isolation mode and the stiffness of the idle mount is switched to absorption mode to minimise vibration in the support (21). The mounts can be mechanical mounts such as springs, which are connected or disconnected according to which mode is required, or can have variable stiffness, for example a mount whose stiffness is dependent upon a change in potential applied to an electro-rheological fluid causing a change in viscosity of the fluid. The system is particularly suitable for reducing vibration in aircraft or ships.



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VIBRATION ATTENUATION SYSTEM

This invention relates to a vibration attenuation system.

Conventionally, vibration control may be by isolation of a vibrating source from its support using isolating mounts, or by absorbing vibrations in the body itself by attaching an absorber, e.g. for a machine, to absorb vibrations due to the machine's frequency of operation. In some cases both systems are used. These systems for controlling vibration are expensive in terms of space, weight and materials, because each machine requires its own specialised mount and absorbing mass. This is particularly felt in aircraft and ships where space and weight are at a premium.

In accordance with the present invention, a vibration attenuation system comprises at least one operative machine, one idle machine and a support; wherein each machine is mounted on the support via respective operative and idle mounts; wherein the stiffness of each mount may be switched between an isolation mode and an absorption mode; and wherein the stiffness of the operative mount is switched to isolation mode and the stiffness of the idle mount is switched to absorption mode, such that vibration in the support is minimised.

The present invention uses an idle machine and its mount to absorb vibrations in another operative machine installed on the same support. The absorption mass and associated mounting of the prior art systems are no longer required, thereby reducing the overall size, weight and cost of the system.

The stiffness of each mount may be varied by disconnecting one part of the mount from the support and connecting another part of the mount dependent on the desired mode of operation, but preferably, each of the operative and idle mounts comprise a single mount, the stiffness of which is controllable.

This further reduces the degree of redundancy in the system by using the same mount, but altering its stiffness, rather than the mount having two different parts, only one of which is in use at any time.

Preferably, each mount comprises controllable means for controlling the stiffness of the mount.

Preferably, the controllable means comprises electro-rheological fluid.

Preferably, the stiffness of the idle mount may be switched to one of a plurality of stiffness values. This allows the idle machine and its mounting to be used as an absorber for machines having different speeds of operation, which are on the same mount.

Preferably, the stiffness of the idle mount in absorption mode is tuned for the operating frequency of the respective operative machine.

This maximises vibration absorption and allows the stiffness to be tuned to specific machines.

Preferably, the support is rigid.

Examples of a vibration attenuation system in accordance with the present invention will now be described and contrasted with conventional vibration control system with reference to the accompanying drawings in which.-

Figure 1 is a first conventional vibration control system;

Figure 2 is a second conventional vibration control system;

Figure 3 is a first example of a vibration control system according to the invention;

Figure 4 is a second example of a vibration control system according to the invention;

Figure 5 shows in more detail a mount for the system of Fig. 3 or Fig. 4; and

Figure 6 shows in more detail an alternative mount for the system of Fig. 3 or Fig. 4.

A conventional vibration control system is shown in Fig. 1 in which a machine 1 is mounted to a support 2, which is fixed at both ends 3. The machine 1 has a mass m, and is attached via a first mounting 4 of stiffness k_1 to the support 2. A dummy weight 5 of mass m_2 is attached to the support 2 via a second mounting 6 of stiffness k_2. Usually, to minimise vibration in the support, the mass of the dummy weight 5 and the stiffness of the second mounting 6 are chosen such that:

$$\frac{(k_2)^{1/2}}{(m_2)^{1/2}} = 2\pi f$$

where m is mass in kg, k is stiffness in kgs^{-2} and f is the frequency to be controlled, such as the fundamental operating frequency of the machine.

A more complex vibration control system is shown in Fig. 2 in which first and second machines 9,10 are mounted on a support 7 which is fixed at both ends 8. The first and second machines 9, 10 are attached to the support via first and second mountings 11,12 and first and second dummy weights 13,14 are attached to the support through third and fourth mountings 15,16. Such an arrangement may be extended to multiple machines, but it requires a dummy weight and mounting for each machine. The disadvantages of the systems shown in Figs.1 and 2 are the extra

space, cost and weight associated with the dummy masses and their vibration mountings. This problem is accentuated when a machine is idle and particularly where a machine is a backup for another and thus unlikely to be operating all that often. This is common on aircraft or ships which need backup machines in place, but have limitations on space and weight.

An example of a vibration attenuation system in accordance with the present invention is shown in Fig. 3. The system has a pair of machines 17,18 mounted via respective mounts 19,20 to a support 21 which is fixed at both ends 22. In use, one of the machines 17 is operative and the other machine 18 is idle. The stiffness of the mount supporting the idle machine 18 is switched to an absorption mode which is adapted to the frequency of operation of the operative machine 17. A mount with variable stiffness may be produced in several ways, such as switching between two mechanical mounts both connected to the idle machine, controlling hydraulic fluid in the mount or using a mount containing electro-rheological fluid which has different stiffness properties according to the voltage applied across it.

In Fig. 4, a support 23 has multiple machines 25 mounted via respective mounts 24. The stiffness of each of these mounts 24 can be varied according to which machine is idle and which is operative, so that where machines are run at different times of day for different purposes, a machine not in use provides vibration absorption for one which is.

Fig. 5 shows an example of a mechanical mount for the present invention, e.g. springs or other resilient couplings, such as rubber. One spring 27, which has a stiffness suitable for the frequency of operation of an operative machine 30, is connected between a support 29 and an idle machine 28, and another spring 26 is disconnected at one end, by hand or by an automatic switch. On the operative machine an isolation spring 31 is connected and another spring 32 is disconnected. If the operative machine 30 became idle and the idle machine 28 was brought into operation, then the connected springs 27,31 would be disconnected and the other springs 31,32 connected.

Fig. 6 illustrates a mount whose stiffness is controlled using electro-rheological fluid. An example of an electro-rheological fluid is silica spheres in water and glycerol. The mount comprises a flexible housing 33, e.g. a rubber bladder, which contains the electro-rheological fluid 34. This fluid has the property that application of a potential to it causes a change in viscosity. This property can be used to alter the stiffness of the mount according to the function it is to perform. The potential can be made

continuously variable by inserting a rheostat 35 in the circuit as shown in Fig. 6a so that the viscosity may be tuned to the stiffness required for a particular machine or a multiway switch 36 as shown in Fig. 6b can be connected to fixed predefined potentials. When a mount is to act as an isolator, a first potential is applied, but if subsequently the same mount was to act as an absorber, then a different potential is applied and the viscosity of the liquid changes. This type of switching is preferable to the use of different mechanical springs or resilient materials because there is no redundancy, so reducing weight and saving-space.

CLAIMS

1. A vibration attenuation system, the system comprising at least one operative machine (17), one idle machine (18) and a support (21); wherein each machine (17,18) is mounted on the support (21) via respective operative and idle mounts (19,20); wherein the stiffness of each mount may be switched between an isolation mode and an absorption mode; and wherein the stiffness of the operative mount (19) is switched to isolation mode and the stiffness of the idle mount (20) is switched to absorption mode, such that vibration in the support (21) is minimised.

2. A system according to claim 1, wherein each of the operative and idle mounts comprise a single mount, the stiffness of which is controllable.

3. A system according to any preceding claim, wherein each mount comprises controllable means for controlling the stiffness of the mount.

4. A system according to claim 3, wherein the controllable means comprises electro-rheological fluid.

5. A system according to claim 4, wherein the electro-rheological fluid comprises silica spheres in water and glycerol.

6. A system according to any preceding claim, wherein the stiffness of the idle mount may be switched to one of a plurality of stiffness values.

7. A system according to any of claims 1 to 6, wherein the stiffness of the idle mount (20) in absorption mode is tuned for the operating frequency of the respective operative machine.

8. A system according to any preceding claim, wherein the support (21) is rigid.

Fig.1.
PRIOR ART

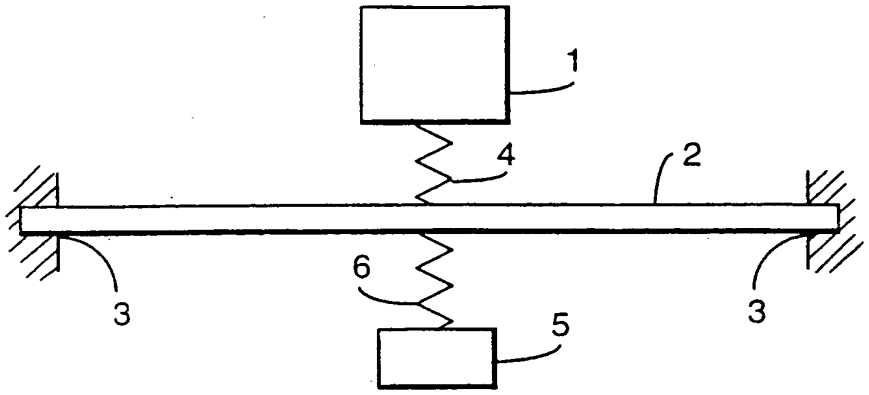


Fig.2.
PRIOR ART

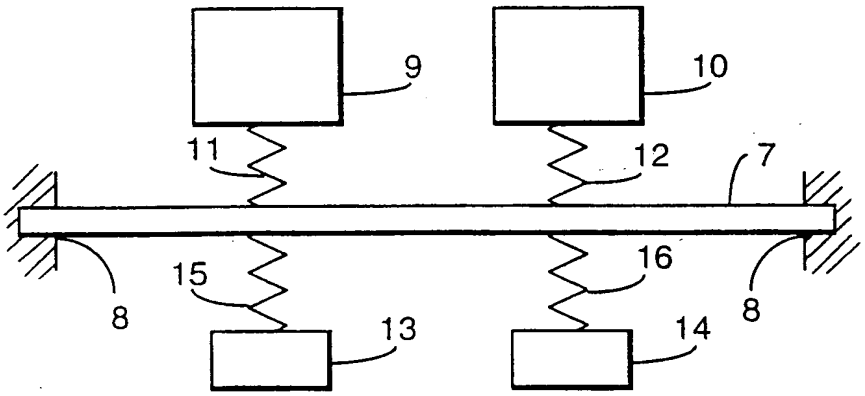


Fig.3.

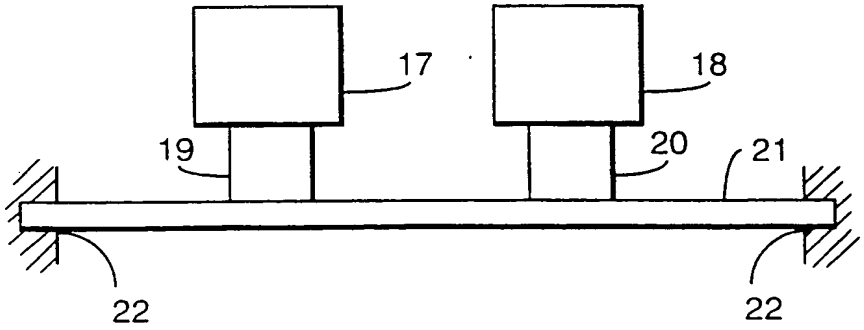


Fig.4.

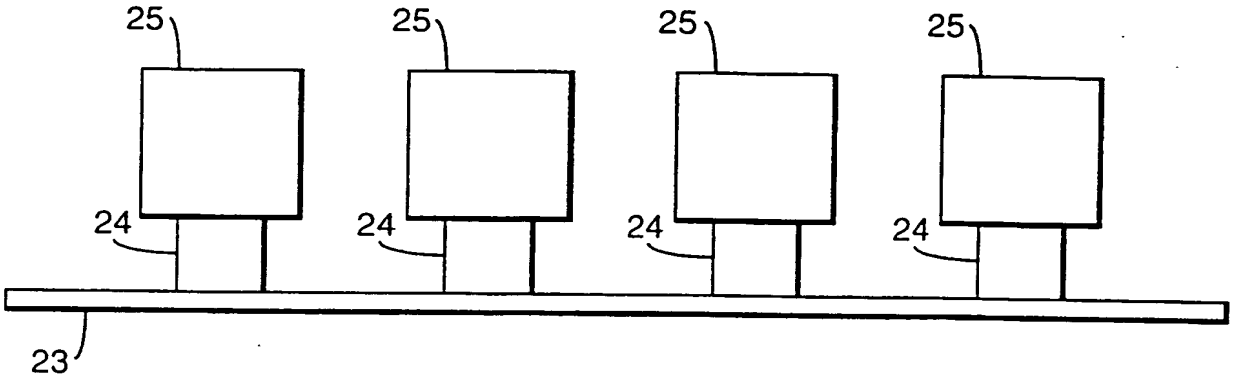


Fig.5.

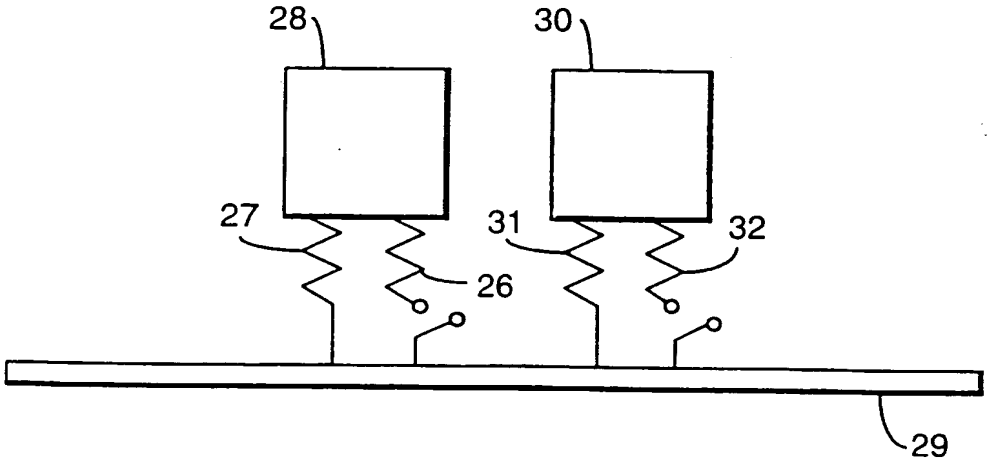


Fig.6(a).

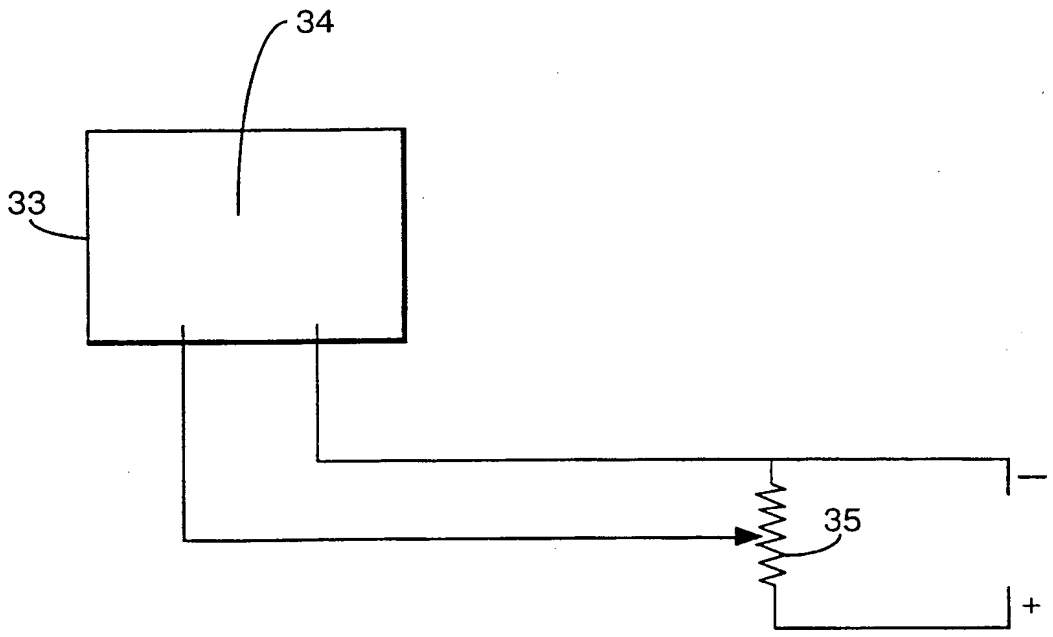
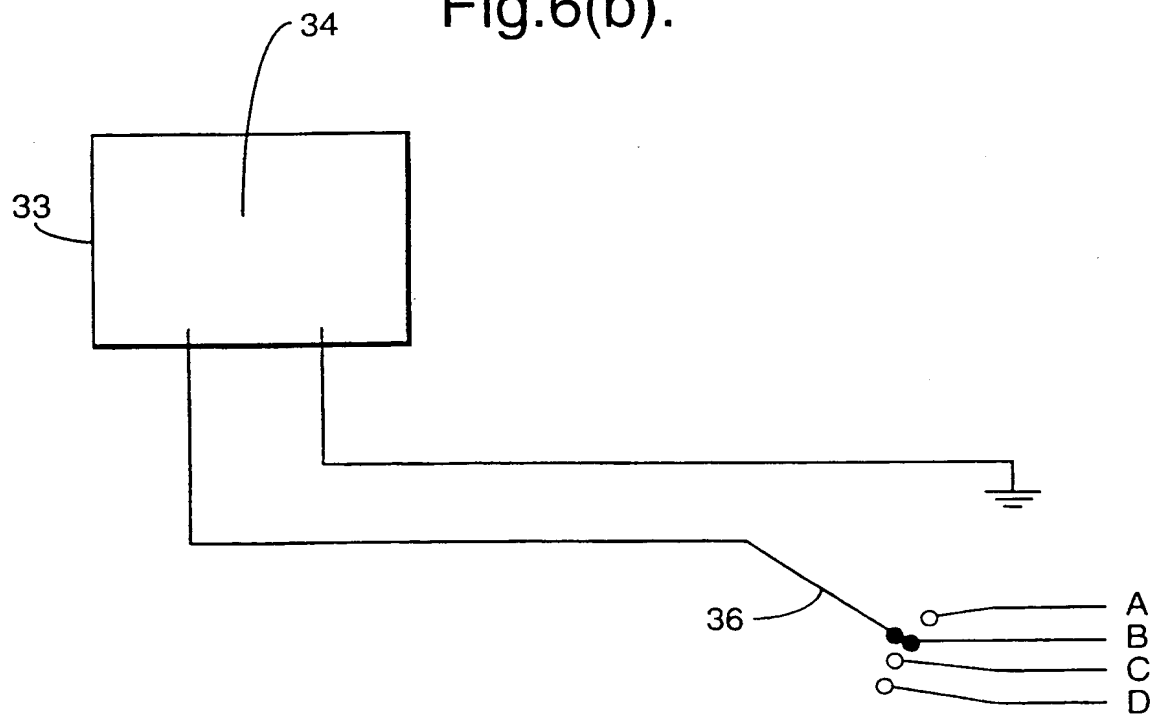


Fig.6(b).



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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
F16F 15/00, 15/027, 7/10, G10K 11/178

A3

(11) International Publication Number: WO 98/16760

(43) International Publication Date: 23 April 1998 (23.04.98)

(21) International Application Number: PCT/GB97/02730

(22) International Filing Date: 6 October 1997 (06.10.97)

(30) Priority Data:
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Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(88) Date of publication of the international search report:
22 May 1998 (22.05.98)

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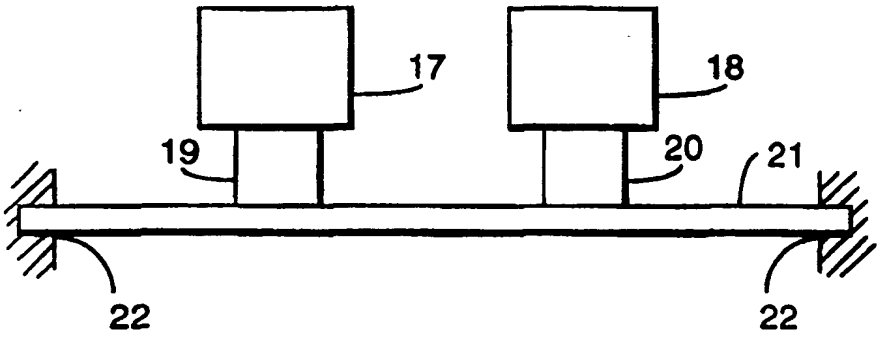

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INTERNATIONAL SEARCH REPORT

Inter -nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16F15/00 F16F15/027 G10K11/178 F16F7/10

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Documentation searched other than minimumdocumentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 34769 A (LORD CORP) 21 December 1995 see the whole document	1-3
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Y	US 5 547 049 A (WEISS KEITH D ET AL) 20 August 1996 see the whole document see column 11, line 53 see column 12, line 63	4-8

A	US 5 505 871 A (HARDER C ROSS ET AL) 9 April 1996 see column 1, line 55 - column 2, line 7	4,5

A	US 4 930 741 A (YOUNG SHELDON E ET AL) 5 June 1990 see the whole document see column 3, line 48 - column 4, line 8	1-4,6,8

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